Biological Assessment Report

Blackberry Creek
Jasper County

2010 – 2011

Prepared for:

Missouri Department of Natural Resources
Division of Environmental Quality
Water Protection Program
Water Pollution Control Branch

Prepared by:

Missouri Department of Natural Resources
Division of Environmental Quality
Environmental Services Program
Water Quality Monitoring Section

Table of Contents

Tables

Figures

Attachments

1.0 Introduction

At the request of the Water Protection Program (**WPP**), the Environmental Services Program (**ESP**) Water Quality Monitoring Section (**WQMS**) conducted a biological assessment of Blackberry Creek. Blackberry Creek is a small tributary of the Spring River, located in the Ozark/Neosho Ecological Drainage Unit (**EDU**) and originates near the town of Asbury. The stream is designated as a Class C stream (WBID 3184) in the Missouri Water Quality Standards (MDNR 2010a) for 6.5 miles starting just upstream of Redbud Road to the confluence with the Spring River (Figure 1). Designated uses for Blackberry Creek are "warm water aquatic life protection, human health/fish consumption, livestock and wildlife watering, and class B whole body contact" (MDNR 2010a). Blackberry Creek was included on the 2008 303(d) list for chloride and sulfate+chloride for the upstream 3.5 miles of WBID 3184.

1.1 Study Area/Justification

The Blackberry Creek watershed is primarily rural and most of the land use is made up of cropland (Figure 2). The primary source of pollutants in the watershed is thought to be the fly ash pond for the Asbury coal-fired power plant which is owned by Empire District Electric Company (**EEC**). The fly ash pond is located on Blackberry Creek just upstream of the 303(d) listed segment. Both sulfate and chloride are present in fly ash, which is a product of burning coal, and therefore occurs in the fly ash pond. In addition to the fly ash pond, old strip mines north of the power plant could be sources of sulfate and chloride in the watershed.

Water quality monitoring data collected by EEC and the Missouri Department of Natural Resources from 2004 through 2008 found that levels of chloride and sulfate+chloride in Blackberry Creek upstream of the fly ash pond were below water quality standards, but above the water quality standards in some samples collected downstream of the fly ash pond (MDNR 2010b). It should be noted, however, that although sulfate values upstream of the fly ash pond were below water quality standards, they were elevated compared to sulfate data collected at two nearby streams--East Fork Drywood Creek and Little North Fork of the Spring River (MDNR [online]). The East Fork Drywood Creek sample location was located in Prairie State Park (Barton County) and has no mining influence. Little North Fork of the Spring River, located just east of Blackberry Creek, has some possible mining influence in the upper portion of the watershed. Comparisons of sulfate and chloride concentrations among the three water bodies are presented in the Results section.

The Blackberry Creek watershed is located in a transitional zone between the Plains and Ozark ecoregions, with the upper part of the watershed located within the Central Irregular Plains ecoregion and the lower part located in the Ozark Highlands ecoregion (Figure 1). Blackberry Creek is a glide/pool transitional stream located within the Ozark/Neosho EDU, which is an area that is predominantly made up of riffle/pool streams types. Since no glide/pool biological criteria exist in the Ozark/Neosho EDU,

Figure 1
Map of Blackberry Creek and Sampling Stations

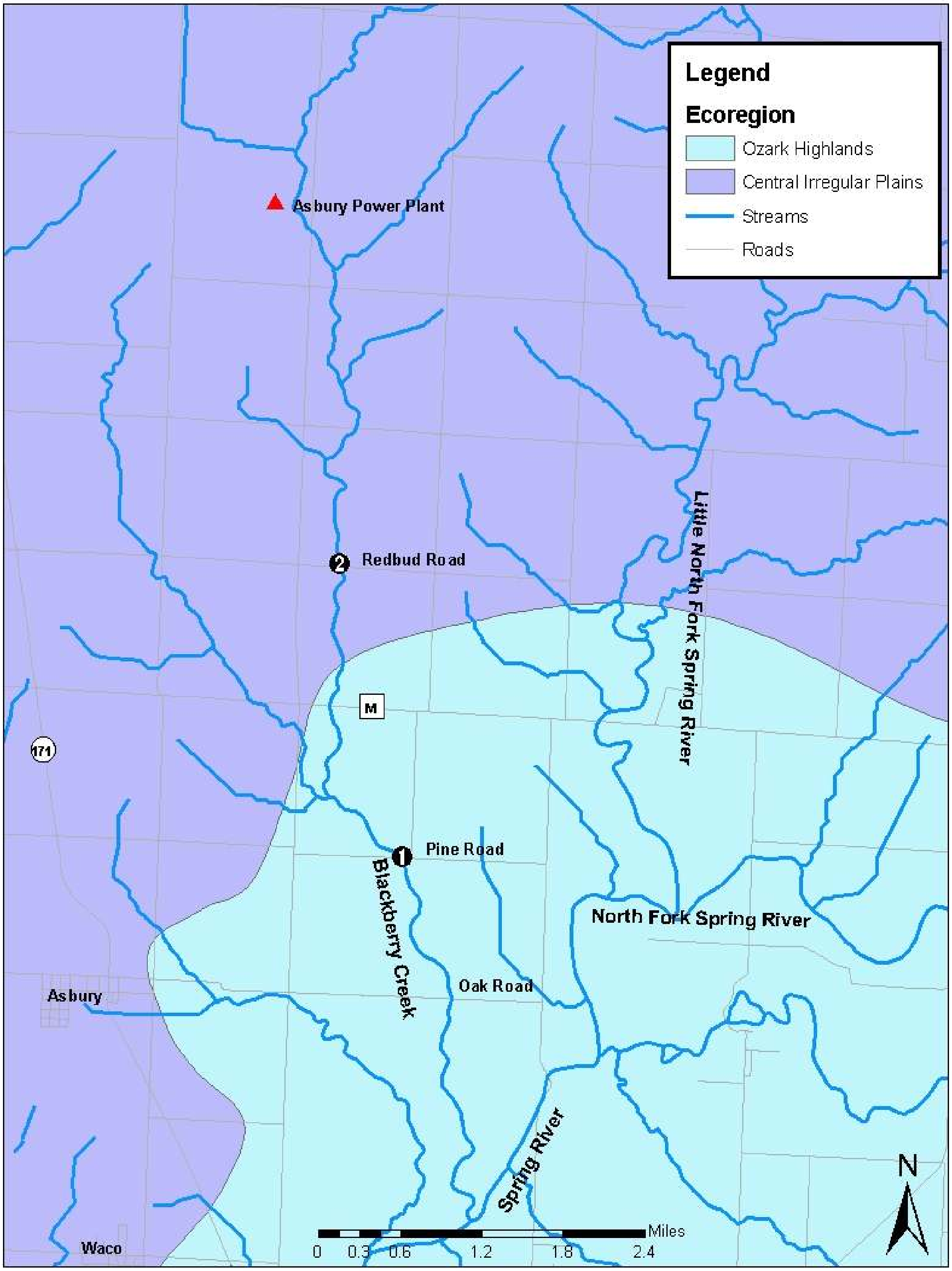
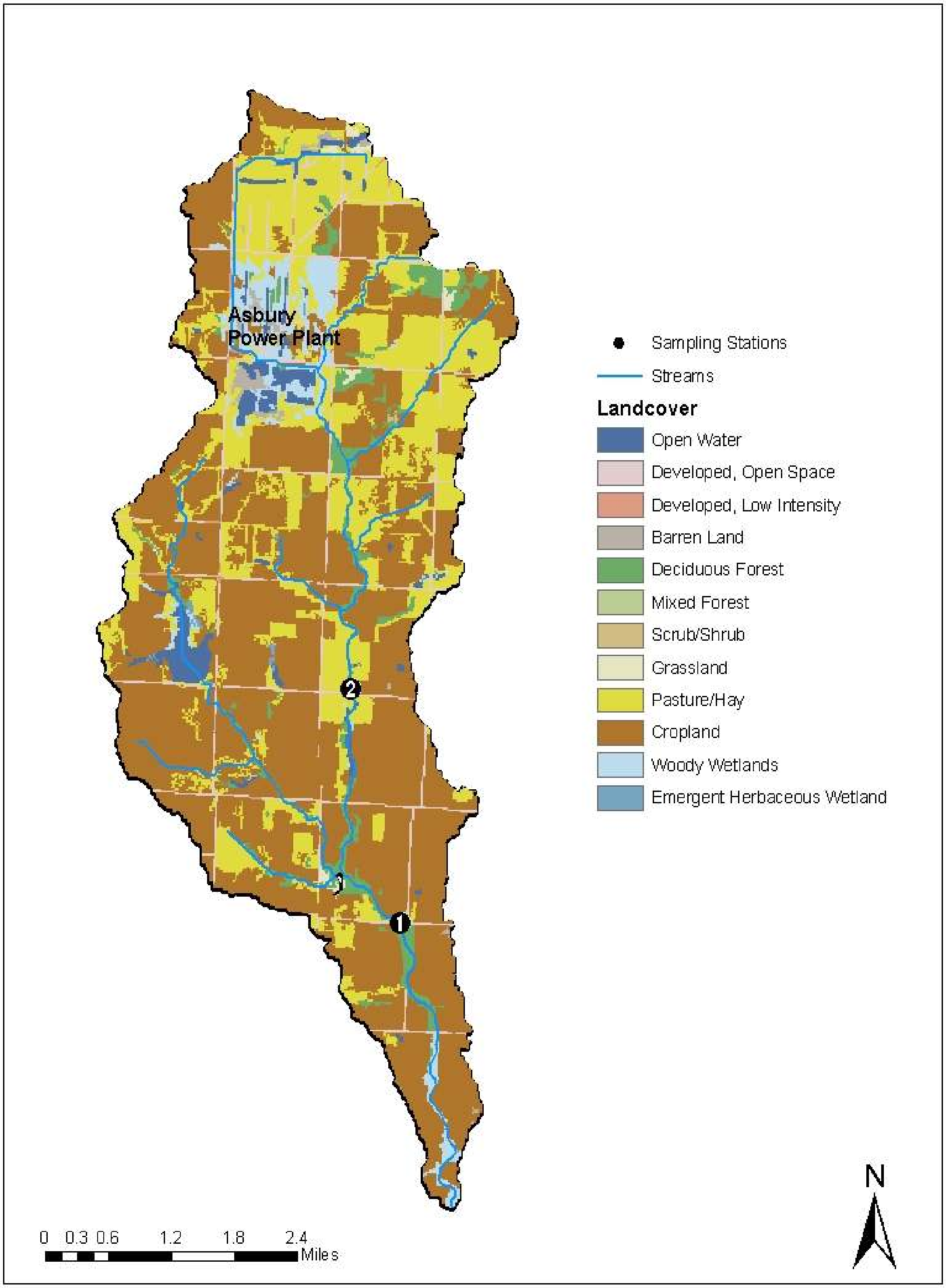


Figure 2
Land Use of the Blackberry Creek Watershed



Blackberry Creek will be assessed using the glide/pool biological criteria for the Central Plains/Osage/South Grand EDU in a manner similar to past studies on the North Fork of the Spring River (MDNR 2004; MDNR 2007).

1.2 Objectives

1. Assess the biological (macroinvertebrate) integrity and water quality of Blackberry Creek downstream of the Asbury Power Plant fly ash pond.

2. Determine stream habitat quality.

1.3 Tasks

1) Conduct a biological assessment on Blackberry Creek.

2) Conduct a stream habitat assessment at the sampling stations to ensure comparability of aquatic habitats.

3) Collect water samples and water quality field measurements at the bioassessment sampling stations.

1.4 Null Hypotheses

1) The macroinvertebrate community will not differ between longitudinally separate reaches of Blackberry Creek.

2) The macroinvertebrate community in Blackberry Creek will not differ from the glide/pool biological criteria for the Central Plains/Osage/South Grand EDU.

3) The stream habitat assessment scores will not differ between longitudinally separate reaches of Blackberry Creek.

4) The stream habitat assessment scores in Blackberry Creek will not differ from Little Drywood Creek, a glide/pool biological criteria reference stream in the Central Plains/Osage/South Grand EDU.

5) Physicochemical water quality in Blackberry Creek will meet the Water Quality Standards (**WQS**) of Missouri (MDNR 2010a).

6) Physicochemical water quality will not differ between longitudinally separate reaches of Blackberry Creek.

2.0 Methods

Carl Wakefield and Mike Irwin of the Biological Assessment Unit, Water Quality Monitoring Section, Missouri Department of Natural Resources, Division of Environmental Quality, Environmental Services Program conducted this study.

2.1 Study Timing

Macroinvertebrate and discrete water quality samples were collected at the sampling stations once during the fall 2010 and spring 2011 sampling seasons. Fall 2010 sampling was conducted on October 5-6, 2010 and spring 2011 sampling was conducted March 30-31, 2011.

2.2 Station Descriptions

The study area and sampling locations for the Blackberry Creek bioassessment study are shown in Figures 1 and 3. A total of two Blackberry Creek stations were surveyed for bioassessment sampling and water quality.

2.2.1 Bioassessment Sampling Stations

Blackberry Creek #1 – Jasper County: Legal description was NE ¼ Sec. 6, T29N, R33W. Geographic coordinates were UTM zone 15, 0361548 Easting, 4128076 Northing. Station located downstream of Pine Road.

Blackberry Creek #2 – Jasper County: Legal description was SW ¼ Sec. 28, T30N, R33W. Geographic coordinates were UTM zone 15, 0360786 Easting, 4131546 Northing. Station located upstream of Redbud Road.

2.3 MoRAP Aquatic Ecological Classification

The aquatic ecological classification developed by the Missouri Resource Assessment Partnership (**MoRAP**) is a classification system that divides the aquatic resources of Missouri into distinct regions. It has seven levels of classification starting at large regions and then dividing them into smaller sub-regions (Sowa et al. 2004). The following are the seven levels of classification in hierarchical order: zone, subzone, region, aquatic subregions, EDU, Aquatic Ecological Systems (**AES**), and Valley Segment types (**VST**). The levels of classification are based on biology, zoogeography, taxonomic composition, geology, soils, and groundwater connection. Some levels of the hierarchical system use geology and soils to classify and other levels use biology and taxonomic composition of aquatic communities. Ecological Drainage Units and AES are the two levels of the classification that will be assessed in detail for this study.

2.3.1 Ecological Drainage Unit

The EDU is level five of the classification hierarchy and is based on geographical variation of the taxonomic composition of the level four subregions. An EDU is a region in which aquatic biological communities and habitat conditions can be expected to be similar. Table 1 shows the land cover percentages from the Ozark/Neosho EDU, Little Drywood Creek biological criteria reference station watershed for the Central Plains/Osage/South Grand EDU, and the watersheds of the Blackberry Creek sampling stations. Land cover data were derived from Thematic Mapper satellite data from 2000 to 2004 for the entire Ozark/Neosho EDU and from the 2001 national landcover database for the Blackberry Creek sampling stations and Little Drywood Creek reference station watersheds. The land use at the Blackberry Creek sampling stations was much higher

Figure 3
Blackberry Creek and Little Drywood Creek Bioassessment and Stream Habitat Assessment Locations

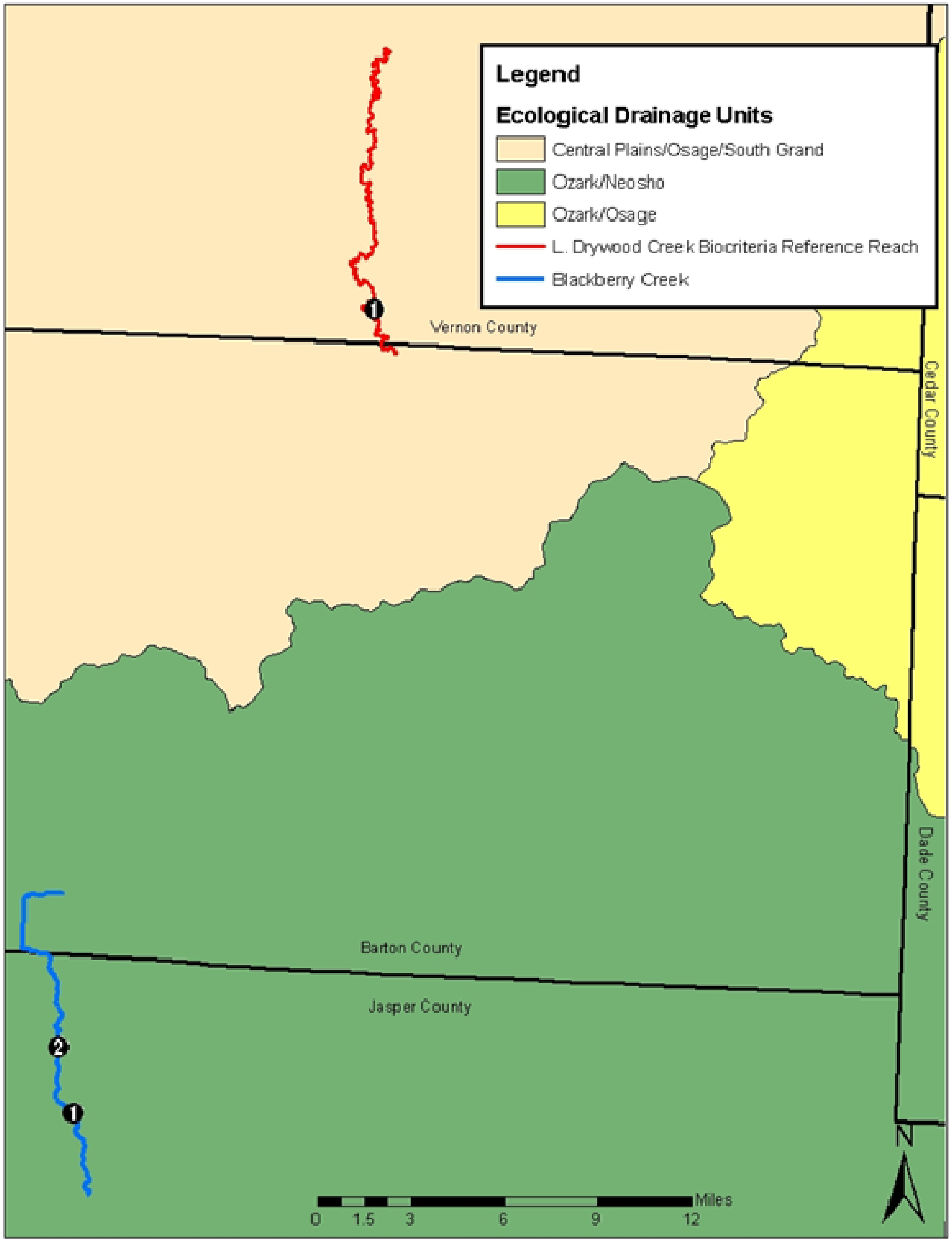


Table 1
Percent Land Cover

Land Cover	Urban	Crops	Grassland	Forest	Wetland
Ozark/Neosho EDU	4	15	52	25	0
Little Drywood Creek #1	3	30	44	20	1
Blackberry Creek #1	4	60	26	4	4
Blackberry Creek #2	4	44	38	5	6

for percent crops and much lower for percent forest than Little Drywood Creek and the entire Ozark/Neosho EDU. Grassland was lower at the Blackberry Creek sampling stations than both the Little Drywood Creek reference station and the entire Ozark/Neosho EDU.

2.3.2 Aquatic Ecological Systems

Aquatic Ecological Systems are level six of the classification hierarchy and classify aquatic systems into AES types based on geology, soils, landform, and groundwater influence. Blackberry Creek is located in the South Deepwater Creek AES type, which is predominately found in the plains regions of Kansas and Missouri (Sowa and Diamond 2006). The South Deepwater Creek AES type also includes the Little Drywood Creek biological criteria reference reach. The South Deepwater Creek AES type is made up of relatively flat to rolling plains with soil textures primarily made up of silt loams with very slow to moderate infiltration rates. This AES type historically was made up of oak, hickory forest and prairie.

2.4 Stream Habitat Assessment

A standardized assessment procedure was followed as described for glide/pool habitat in the Stream Habitat Assessment Project Procedure (**SHAPP**) (MDNR 2010c). The habitat assessments were conducted at the sampling stations on October 5-6, 2010.

2.5 Biological Assessment

Biological assessments consist of macroinvertebrate collection and physicochemical sampling for two sample periods.

2.5.1 Macroinvertebrate Collection and Analysis
A standardized macroinvertebrate sample collection and analysis procedure was followed as described in the Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (**SMSBPP**) (MDNR 2010d) for glide/pool (**GP**) streams. Three standard habitats—depositional substrate in non-flowing water (**NF**), large woody debris (**SG**), and root-mat (**RM**)—were collected at the sampling stations.

Macroinvertebrate data were analyzed using two methods. The first analysis was calculating the Macroinvertebrate Stream Condition Index (**MSCI**) using the biological criteria for perennial/wadeable streams from the Central Plains/Osage/South Grand EDU using the four general biological metrics found in the SMSBPP (MDNR 2002). The four general biological metrics used and found in the SMSBPP are: 1) Taxa Richness (**TR**); 2) Ephemeroptera/Plecoptera/Trichoptera Taxa (**EPTT**); 3) Biotic Index (**BI**); and 4) Shannon Diversity Index (**SDI**). The second analysis was an evaluation of macroinvertebrate community composition by percent composition of dominant macroinvertebrate groups. Comparisons of the macroinvertebrate community between the Blackberry Creek test stations were made.

2.6 Physicochemical Data Collection and Analysis

2.6.1 *In situ* Water Quality Measurements
During each sampling period, *in situ* water quality measurements were collected at each of the bioassessment sampling stations. Field measurements included water temperature (°C), dissolved oxygen (mg/L), conductivity (µS/cm), and pH.

2.6.2 Water Chemistry
Grab samples of stream water were collected and returned for analyses to ESP's Chemical Analysis Section. Samples from the bioassessment sampling stations were analyzed for total suspended solids, turbidity, chloride, sulfate, hardness, acidity, total phosphorus, ammonia-N, nitrate + nitrite-N, and total nitrogen. Procedures outlined in Field Sheet and Chain-of-Custody Record, Standard Operating Procedure (**SOP**) MDNR-ESP-002 (MDNR 2010e) and Required/Recommended Containers, Volumes, Preservatives, Holding Times, and Special Sampling Considerations, SOP MDNR-ESP-001 (MDNR 2009) were followed when collecting water quality samples. Stream velocity was measured at each station during the survey period using a Marsh-McBirney Flo-Mate™ Model 2000. Discharge was calculated per the methods in SOP MDNR-ESP-113, Flow Measurement in Open Channels (MDNR 2010f).

2.7 Data Analysis and Quality Control
The physicochemical data were examined by analyte to determine whether stations had violations of the Missouri Water Quality Standards (MDNR 2010a). Sampling stations that had values not in compliance with the Water Quality Standards will be discussed with possible influences being identified.

3.0 Results

3.1 Stream Habitat Assessment

Habitat assessment scores and physical characteristics for the Blackberry Creek test stations and the Little Drywood Creek biological criteria reference reach station are shown in Tables 2 and 3. The Little Drywood Creek habitat assessment was performed on a class C stream reach located in the upper part of the biological criteria stream section in southern Vernon County (Figure 3). Habitat assessment data were collected in October 2010 with Carl Wakefield and Mike Irwin performing the scoring. SHAPP guidance states that test stations scoring at least 75 percent of the total score of reference/control stations should support a similar biological community. Because Blackberry Creek habitat assessment scores were greater than 75 percent of the Little Drywood Creek habitat score, the test stations should support a similar macroinvertebrate community. Most of the Blackberry Creek #1 habitat metrics were in the optimal or suboptimal range except for vegetative protection, channel sinuosity, and pool variability. Blackberry Creek #2 had a much lower stream habitat score partially due to two habitat metrics, epifaunal substrate and sediment deposition, scoring in the marginal and poor categories, respectively. These metrics indicated that a high amount of sedimentation had occurred within the stream reach. Blackberry Creek is impounded downstream of the sampling reach and these two habitat metrics gave evidence that the dam has altered the hydrology of the stream reach. Other metrics that scored in the marginal to poor category at Blackberry Creek #2 were channel sinuosity, vegetative protection, and the right bank riparian zone.

3.2 Macroinvertebrate Biological Assessment

3.2.1 Semi-quantitative Macroinvertebrate Stream Bioassessment Project Procedure (SMSBPP)

A Macroinvertebrate Stream Condition Index **(MSCI)** score was calculated for Blackberry Creek test stations using the glide/pool perennial/wadeable biological criteria for the Central Plains/Osage/South Grand EDU (Tables 4 and 5). Blackberry Creek test stations had fully supporting MSCI scores during both sampling seasons. MSCI scores were 20 at test station #1 and 16 at test station #2 during the fall 2010 sampling season. During the spring 2011 sampling season, test station #1 had an MSCI score of 18 and station #2 had a score of 16. The lower MSCI score at test station #2 was caused by lower TR and SDI values during the fall 2010 sampling season and by EPTT and BI during the spring 2011 sampling season.

Table 2
Predominant Category Habitat Values, Category Habitat Scores, and Total Habitat Scores from Stream Habitat Assessments for the Blackberry Creek Test Stations and the Little Drywood Creek Biological Criteria Reference Station

	Blackberry Creek #1	**Blackberry Creek #2**	**L. Drywood Creek #1**
Sample Date	10/06/10	10/05/10	10/05/10
Stream Habitat Parameters			
Epifaunal Substrate/Available Cover	II (15)	III (7)	III (6)
Pool Substrate Characterization	I (19)	II (14)	I (16)
Pool Variability	III (9)	II(11)	I (16)
Sediment Deposition	II (15)	IV (3)	II (12)
Channel Flow Status	I (19)	I (17)	II (12)
Channel Alteration	II (15)	II (13)	I (20)
Channel Sinuosity	IV (3)	IV (5)	III (9)
Bank Stability – Left Bank	II (8)	I (10)	I (10)
Bank Stability – Right Bank	II (6)	II (8)	II (6)
Vegetative Protection – Left Bank	IV (1)	IV (2)	IV (2)
Vegetative Protection – Right Bank	IV (1)	III (4)	IV (0)
Riparian Zone Width – Left Bank	I (10)	I (9)	I (10)
Riparian Zone Width – Right Bank	I (9)	IV (1)	I (10)
Total Habitat Score	130	104	129

Habitat parameter categories range from I to IV with category I = optimal, category II = suboptimal, category III = marginal, and category IV = poor. Habitat parameter scores are listed in parentheses and range from 0 to 20 except for vegetative protection and riparian zone categories which range from 0 to 10.

Table 3
Physical Characteristics of the Blackberry Creek Bioassessment Sampling Reaches Based on Values from the MoRAP Valley Segment Types (VST) Geographic Information Systems (GIS) Layer

	Blackberry Creek #1	Blackberry Creek #2	L. Drywood Creek #1
Watershed Area (mi^2)	22	11	55
Strahler Order	3	2	4
Link Magnitude	8	5	27
Relative Gradient	Low	Low	Low
Sinuosity (mile/mile)	1.14	1.13	1.96
Temperature Regime	Warm	Warm	Warm
Stream Size	Creek	Creek	Creek
Flow Regime	Permanent	Permanent	Permanent
Geology	Limestone	Limestone	Limestone

Table 4
Fall 2010 Glide/Pool Central Plains/Osage/South Grand EDU Perennial/Wadeable Biological Criteria, Biological Support Categories, and Macroinvertebrate Stream Condition Index (MSCI) Scores at the Blackberry Creek Test Stations

Stream and Station Number	Sample No.	TR	EPTT	BI	SDI	MSCI	**Support**
Blackberry Creek #1	1004125	67	9	7.40	2.98	20	F
Blackberry Creek #2	1004124	55	9	7.30	2.78	16	F
Metric Score=5	If	>55	>6	<7.70	>2.87	20-16	**F**ull
Metric Score=3	If	55-27	6-3	7.70-8.90	2.87-1.43	14-10	**P**artial
Metric Score=1	If	<27	<3	>8.90	<1.43	8-4	**N**on

MSCI Scoring Table (in light gray) developed from BIOREF stream samples (n=15); TR=Taxa Richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

Table 5
Spring 2011 Glide/Pool Central Plains/Osage/South Grand EDU Perennial/Wadeable Biological Criteria, Biological Support Categories, and Macroinvertebrate Stream Condition Index (MSCI) Scores at the Blackberry Creek Test Stations

Stream and Station Number	Sample No.	TR	EPTT	BI	SDI	MSCI	**Support**
Blackberry Creek #1	110343	64	4	7.3	2.60	18	F
Blackberry Creek #2	110344	59	6	7.5	2.85	16	F
Metric Score=5	If	>50	>8	<7.40	>2.53	20-16	**F**ull
Metric Score=3	If	50-25	8-4	7.40-8.70	2.87-1.27	14-10	**P**artial
Metric Score=1	If	<25	<4	>8.70	<1.27	8-4	**N**on

MSCI Scoring Table (in light gray) developed from BIOREF stream samples (n=12); TR=Taxa Richness; EPTT=Ephemeroptera, Plecoptera, Trichoptera Taxa; BI=Biotic Index; SDI=Shannon Diversity Index

3.2.2 Macroinvertebrate Percent and Community Composition

The percent composition of EPTT, sensitive taxa, functional feeding groups (FFG), functional habitat groups (FHG), and the five dominant macroinvertebrate families and taxa at each station are presented in Tables 6 through 9. Values in bold type represent the five dominant macroinvertebrate families and taxa for each station.

The macroinvertebrate community during the fall 2010 sampling season mostly was made up of tolerant taxa. Taxa with biotic index values less than 5.0 made up about 1 percent of the sample at test station #1 and about 3 percent of the sample at test station #2 (Table 6). Taxa with biotic index values between 5.0 and 7.5 made up 50.5 percent at test station #1 and 36.2 percent at test station #2. The percent of samples made up of taxa with biotic index values between 7.5 and 10.0 was 48.6 percent at test station #1 and 60.8 percent at test station #2. Samples collected from biocriteria reference streams had a much higher proportion of intolerant (BI < 2.5) and very tolerant taxa (BI > 9.0) than the Blackberry Creek test stations (Table 6).

Gatherer-collectors were the most common FFG at the Blackberry Creek test stations during the fall 2010 sampling season and were present in slightly higher abundance than the biological criteria data (Table 6). Filterers made up almost a quarter of the sample at test station #1 and were much more common than at test station #2 and the biological criteria reference data. Predators were fairly common in the Blackberry Creek samples with values only slightly lower than reference data. The percentage of scrapers at test station #1 was slightly lower compared to reference conditions and slightly higher than references at test station #2. Shredders made up a small percentage of the Blackberry

Creek samples and were present in much lower numbers compared to reference conditions.

During the fall 2010 sampling season burrowers made up 15 to 20 percent of the Blackberry Creek samples. Burrowers were slightly higher at test station #1 and slightly lower at test station #2 compared to the biological criteria data. Clingers at test station #1 were much higher than test station #2, making up almost 25 percent of the sample and were similar to reference conditions. Climbers ranged from 27 to 34 percent in Blackberry Creek samples, which was much higher than reference conditions. The percentage of sprawlers was much higher at test station #2 and slightly lower at test station #1 compared to reference data. Swimmers made up a much smaller percent of the Blackberry Creek samples than the biological criteria reference samples.

Chironomidae was the most abundant family found in the fall 2010 Blackberry Creek macroinvertebrate samples and was much more abundant at test station #1 than test station #2 (Table 7). Chironomid taxa common in samples included *Tanytarsus* at test station #1 and *Dicrotendipes* and *Tribelos* at both sampling stations. Mayflies, made up of primarily *Caenis latipennis*, were much more abundant at test station #2 than test station #1. Lymnaeid and physid snails were fairly abundant at test station #1 whereas the elmid beetle *Dubiraphia* and the amphipod *Hyalella azteca* were common at test station #2. Damselflies from the family Coenagrionidae also were common at both Blackberry Creek sampling stations.

The macroinvertebrate community was mostly made up of tolerant taxa during the spring 2011 sampling season. Taxa with biotic index values less than 5.0 made up about 2 percent of the sample at test station #1 and about 5.5 percent of the sample at test station #2 (Table 8). Taxa with biotic index values between 5.0 and 7.5 made up 44 percent at test station #1 and 34 percent at test station #2. Taxa with biotic index values between 7.5 and 10.0 made up 54 percent of samples at test station #1 and 61 percent at test station #2. Biocriteria reference samples had a much higher proportion of intolerant taxa (BI < 2.5) than the Blackberry Creek test stations. The biocriteria samples and Blackberry Creek #2 had a much higher proportion of very tolerant taxa (BI > 9.0) than Blackberry Creek #1.

Table 6
Biological Metric Values for Sensitive Taxa, Functional Feeding Groups (FFG), and Functional Habitat Groups (FHG) at the Blackberry Creek Test Stations and the Biological Criteria Reference Samples, Fall 2010

Variable-Station	**Biocriteria Reference Data**	**Blackberry Creek #1**	**Blackberry Creek #2**
Sample Number		1004125	1004124
Sensitive Taxa			
% Biotic Index >9.0	20.75	17.23	11.61
% Biotic Index 7.5-9.0	40.12	31.39	49.21
% Biotic Index 5.0-7.5	31.97	50.50	36.22
% Biotic Index 2.5-5.0	1.57	0.89	2.85
% Biotic Index <2.5	5.59	0	0.10
FFG Metrics			
% Filterers	13.54	23.81	11.10
% Gatherer-Collectors	40.82	41.35	43.57
% Parasites	2.45	1.27	1.30
% Piercers	3.10	2.66	3.96
% Predators	13.13	11.15	12.21
% Scrapers	14.93	13.11	18.77
% Shredders	11.06	3.29	1.23
FHG Metrics			
% Burrowers	17.47	20.34	15.22
% Clingers	26.93	24.50	13.99
% Climbers	12.40	27.08	33.70
% Divers	0.09	0.21	0.20
% Skaters	0.09	0	0.07
% Sprawlers	13.51	10.24	23.91
% Swimmers	6.68	2.36	0.95

Table 7
Percent EPT, Dominant Macroinvertebrate Families, and Taxa at the Blackberry Creek Test Stations during the Fall 2010 Sampling Season

Variable-Station	**Biotic Index**	**Biocriteria Data**	**Blackberry Creek #1**	**Blackberry Creek #2**
EPT Metrics				
% EPT		20.8 ± 0.9	9.5	25.7
% Ephemeroptera		19.2 ± 0.8	7.1	25.0
% Plecoptera		0	0	0
% Trichoptera		1.6 ± 0.2	2.4	0.7
Percent Dominant Families				
Chironomidae		**37.0 ± 0.7**	**58.5**	**35.6**
Tubificidae		**9.0 ± 0.4**	2.8	0.8
Heptageniidae		**8.3 ± 0.5**	0.6	0.2
Caenidae		**5.9 ± 0.5**	**3.4**	**23.3**
Hyalellidae		**4.4 ± 0.3**	0.5	**9.7**
Elmidae		**4.4 ± 0.5**	2.1	**9.9**
Lymnaeidae		0.1 ± 0.0	**7.7**	0
Physidae		2.2 ± 0.2	**5.9**	2.1
Coenagrionidae		4.4 ± 0.3	**4.3**	**8.2**
Percent Dominant Taxa				
Stenacron	7.1	**7.9 ± 0.5**	0.3	0.2
Glyptotendipes	8.5	**7.6 ± 0.6**	0.2	0.5
Tubificidae	9.2	**7.1 ± 0.3**	2.3	0.6
Dicrotendipes	7.9	**6.1 ± 0.3**	**14.3**	**9.7**
Caenis latipennis	7.6	**5.9 ± 0.5**	3.4	**23.3**
Tanytarsus	6.7	4.0 ± 0.3	**21.9**	4.9
Tribelos	6.6	0.7 ± 0.1	**9.0**	**7.6**
Lymnaeidae	8	0.1 ± 0.0	**7.7**	0
Physella	9.1	2.2 ± 0.2	**5.9**	2.1
Dubiraphia	6.4	4.4 ± 0.5	2.0	**9.8**
Hyalella azteca	7.9	4.4 ± 0.3	0.5	**9.7**

Biocriteria data values are average percent ± standard deviation.

During the spring 2011 sampling season gatherer-collectors were the most common FFG, making up about half of the macroinvertebrates in samples (Table 8). Compared to biological criteria data, gatherer-collector values were slightly lower at test station #1 and similar at test station #2. Filterers were much more common at test stations than reference conditions, making up almost 29 percent of the sample at test station #1 and 15 percent of the sample at test station #2. Scrapers at test stations were slightly lower than reference samples, making up about 9 percent of the sample at test station #2 and 12 percent at test station #1. Predators made up about 4 percent of the samples at both test stations and were slightly lower in abundance than reference conditions. Shredders were present in much lower numbers than biocriteria references at test station #1, making up about 4 percent of the sample. Shredders were present in slightly lower abundance at test station #2, making up about 13 percent of the sample.

During the spring 2011 sampling season burrowers made up about 22 percent of the sample at test station #1 and 27 percent at test station #2, which was slightly higher than reference samples (Table 8). Clingers were slightly lower in abundance than reference conditions, making up about 25 percent of the sample at test station #1 and 23 percent at test station #2. Climbers were present in much higher numbers than reference conditions, making up about 30 percent of the sample at test station #1 and 20 percent of the sample at test station #2. Sprawlers were lower in abundance than reference conditions, making up about 13 percent at test station #1 and 12 percent at test station #2. Swimmers made up a much smaller percent of the Blackberry Creek samples than the biological criteria reference samples.

Chironomidae was the most abundant family found in the spring 2011 Blackberry Creek macroinvertebrate samples and was much more abundant at test station #1 than test station #2 (Table 9). Chironomids made up a similar percent of the sample at test station #2 compared to reference conditions, but were much higher at test station #1. Chironomids common in the samples included *Tanytarsus* at test station #1, *Dicrotendipes* at both sampling stations, and the *Cricotopus/Orthocladius* group at test station #2. The only common EPTT was the mayfly *Caenis latipennis*, which was much more abundant in test stations compared to reference data. Tubificid worms were much more abundant at test station #2 compared to both test station #1 and reference data, making up about 15 percent of the sample. Other taxa that were fairly common in test station samples were hydrobiid snails, the chironomid *Cricotopus/Orthocladius* group at test station #1, and the elmid beetle *Dubiraphia* at test station #2.

Table 8
Biological Metric Values for Sensitive Taxa, Functional Feeding Groups (FFG), and Functional Habitat Groups (FHG) at the Blackberry Creek Test Stations and the Biological Criteria Reference Samples, Spring 2011

Variable-Station	**Biocriteria Reference Data**	**Blackberry Creek #1**	**Blackberry Creek #2**
Sample Number		110343	110344
Sensitive Taxa			
% Biotic Index >9.0	25.64	10.11	24.64
% Biotic Index 7.5-9.0	23.63	44.19	36.08
% Biotic Index 5.0-7.5	38.64	43.88	33.85
% Biotic Index 2.5-5.0	9.47	1.52	4.36
% Biotic Index <2.5	2.62	0.30	1.07
FFG Metrics			
% Filterers	7.64	28.66	14.86
% Gatherer-Collectors	52.57	46.30	52.47
% Parasites	1.21	0.73	0.12
% Piercers	1.29	2.26	1.26
% Predators	6.37	4.41	4.21
% Scrapers	13.72	11.65	8.72
% Shredders	16.35	4.24	13.18
FHG Metrics			
% Burrowers	20.99	21.81	27.05
% Clingers	27.28	24.88	22.82
% Climbers	5.24	29.72	20.27
% Divers	0.14	0.34	0.40
% Skaters	0	0	0
% Sprawlers	20.67	13.02	12.28
% Swimmers	1.92	0.41	0.60

Table 9
Percent EPT, Dominant Macroinvertebrate Families, and Taxa at the Blackberry Creek Test Stations during the Spring 2011 Sampling Season

Variable-Station	**Biotic Index**	**Biocriteria Data**	**Blackberry Creek #1**	**Blackberry Creek #2**
EPT Metrics				
% EPT		10.3 ± 0.8	13.8	12.4
% Ephemeroptera		7.9 ± 0.6	11.4	11.7
% Plecoptera		1.3 ± 0.6	0	0
% Trichoptera		1.1 ± 0.1	1.8	0.7
Percent Dominant Families				
Chironomidae		**54.4 ± 2.5**	**67.4**	**54.1**
Tubificidae		**10.3 ± 0.5**	**3.9**	**15.0**
Asellidae		**6.6 ± 1.1**	0	0.7
Simuliide		**5.0 ± 0.5**	0	0
Caenidae		**3.2 ± 0.3**	**11.3**	**11.2**
Hydrobiidae		0.3 ± 0.1	**4.0**	0
Hyalellidae		2.3 ± 0.2	**2.6**	**5.0**
Elmidae		0.4 ± 0.0	0.8	**4.6**
Percent Dominant Taxa				
Cricotopus/Orthocladius grp.	6.5	**21.8 ± 1.5**	**4.0**	**14.6**
Hydrobaenus	9.6	**10.9 ± 0.9**	1.1	0.6
Lirceus	7.7	**6.6 ± 1.1**	0	0.7
Tubificidae	9.2	**6.0 ± 0.3**	2.7	**14.5**
Simulium	4.4	**4.8 ± 0.5**	0	0
Tanytarsus	6.7	1.3 ± 0.1	**26.7**	**6.2**
Dicrotendipes	7.9	1.3 ± 0.1	**24.3**	**15.0**
Caenis latipennis	7.6	3.0 ± 0.3	**11.3**	**11.2**
Hydrobiidae	8	0.3 ± 0.1	**4.0**	0

Biocriteria data values are average percent ± standard deviation.

3.3 Physicochemical Data

Water quality data collected between 1994 and 2011 prior to this study provide some comparison between Blackberry Creek and two nearby streams—East Fork Drywood Creek and Little North Fork of the Spring River (MDNR [online]). Blackberry Creek sulfate concentrations upstream of the fly ash pond averaged 585 mg/L (n=7, range 208-876 mg/L), whereas downstream of the fly ash pond sulfate averaged 997 mg/L (n=31, range 60-2640 mg/L). By comparison, sulfate concentrations from East Fork Drywood Creek averaged 22.4 mg/L (n=21, range 8-48 mg/L) and Little North Fork of the Spring River had sulfate concentrations that averaged 114.4 mg/L (n=20, range 24.4-318 mg/L). With respect to chloride concentrations, only one Blackberry Creek sample collected upstream of the fly ash pond in 2007 was available. The chloride concentration in this upstream sample was 4 mg/L. Downstream of the fly ash pond, Blackberry Creek

chloride concentrations averaged 459 mg/L (n=12, range 45-962 mg/L). In contrast, East Fork Drywood Creek chloride concentrations averaged 3.8 mg/L (n=21, range 0.3-14 mg/L) and North Fork of the Spring River averaged 13.4 mg/L (n=20, range 6.34-23.7 mg/L).

For this study, water samples and field measurements were collected during the fall 2010 and spring 2011 macroinvertebrate sampling periods. Physicochemical results are arranged to demonstrate trends of certain variables that may suggest a source of effects at the Blackberry Creek test stations. Results can be found in Table 10 for the fall 2010 sampling season and Table 11 for the spring 2011 sampling season. Results shown here are for stream discharge, sulfate + chloride, nitrate + nitrite-N, and total nitrogen by season.

3.3.1 Stream Discharge

Discharge was very low at the bioassessment sampling stations during the fall 2010 sampling season. Discharge was <1 cfs at both test stations and could not be measured with a flow meter. Discharge at the bioassessment sampling stations was much higher during the spring 2011 sampling season with a value of 6.9 cfs at test station #1 and 4.4 cfs at test station #2.

3.3.2 Sulfate + Chloride

Sulfate and chloride are linked together in Missouri's Water Quality Standards, with a compliance threshold of 1000 mg/L (MDNR 2010a). Sulfate and chloride were elevated at the Blackberry Creek test stations compared to two local streams, but were below the water quality standard. During the fall 2010 sampling season, sulfate was 707 mg/L at test station #1 and 531 mg/L at test station #2. Chloride was 190 mg/L at test station #1 and 100 mg/L at test stations #2

Sulfate + chloride concentrations were higher at both stations during the fall 2010 sampling season compared to the spring samples, but none exceeded the compliance threshold. The highest sulfate + chloride concentration was 897 mg/L at station #1 during fall 2010. The lowest sulfate + chloride concentration of 274.6 mg/L occurred at station #1 in the spring 2011 sample.

3.3.3 Nitrate + Nitrite-N

Nitrate + nitrite-N was very low during the fall 2010 sampling season with concentrations of 0.01 mg/L at test station #1 and 0.02 mg/L at test station #2 (Table 10). Nitrate + nitrite-N was much higher during the spring 2011 sampling season with concentrations of 0.59 mg/L at test station #1 and 0.51 mg/L at test station #2. Concentrations of nitrate + nitrite-N in spring 2011 for test station #1 were above the U.S. EPA recommended value of 0.24 mg/L for the Level III Ozark Highlands ecoregion (U.S. EPA 2000a) and the spring 2011 value at test station #2 was above the recommended value of 0.23 mg/L for the Level III Central Irregular Plains ecoregion (U.S. EPA 2000b).

3.3.4 Total Nitrogen

Total nitrogen concentrations were lower during the fall 2010 sampling season with values of 0.49 mg/L at test station #1 and 0.56 mg/L at test station #2. During the spring 2011 sampling season, total nitrogen was higher with values of 1.32 mg/L at test station #1 and 0.98 mg/L at test station #2. Total nitrogen concentrations during this study at test station #1 were above the U.S. EPA recommended value of 0.38 mg/L for the Ozarks Highland ecoregion (U.S. EPA 2000a). At test station #2, total nitrogen was below the recommended value for the Level III Central Irregular Plains ecoregion during the fall 2010 sampling season, but was above the recommended value during the spring 2011 sampling season.

Table 10
Physicochemical Variables at the Blackberry Creek Bioassessment Study Sampling Stations, Fall 2010

	Blackberry Creek #1	Blackberry Creek #2
Invertebrate Sample Number	1004125	1004124
Physicochemical Sample Number	1006984	1006983
Sample Date	10/06/10	10/05/10
Sample Time	0815	1415
Ammonia	0.05	0.09
Chloride	190	100
Sulfate	707	531
Total Alkalinity as $CaCO_3$	92.0	77.0
Dissolved Oxygen	5.41	5.97
Discharge (cfs)	<1	<1
pH (Units)	6.9	7.2
Acidity	<5*	<5*
Conductivity (µmhos/cm)	2080	1445
Temperature (°C)	12.1	16.2
Turbidity (NTU)	2.11	4.15
Total Suspended Solids	<5*	<5*
Nitrate + Nitrite	0.01**	0.02**
Total Nitrogen	**0.49**	**0.56**
Total Phosphorus	<0.01*	0.06

*Below detectable limits
**Estimated value, detected below Practical Quantitation Limit
Units mg/L unless otherwise noted. Values in bold are elevated compared to water quality standards or U.S. EPA recommended reference condition values.

Table 11
Physicochemical Variables at the Blackberry Creek Bioassessment Study Sampling Stations, Spring 2011

	Blackberry Creek #1	Blackberry Creek #2
Invertebrate Sample Number	110343	110344
Physicochemical Sample Number	1104193	1104192
Sample Date	03/31/11	03/30/11
Sample Time	0830	1600
Ammonia	0.20	0.16
Chloride	48.6	107
Sulfate	226*	444
Total Alkalinity as $CaCO_3$	39.0	50.0
Dissolved Oxygen	9.95	10.68
Discharge (cfs)	6.92	4.36
pH (Units)	7.30	7.90
Acidity	<5**	<5**
Conductivity (µmhos/cm)	674	1292
Temperature (°C)	6.4	8.1
Turbidity (NTU)	16.2	6.17
Total Suspended Solids	5.0	6.00
Nitrate + Nitrite	**0.59**	**0.51**
Total Nitrogen	**1.32**	**0.98**
Total Phosphorus	0.09	0.05***

*Sample was diluted during analysis
**Below detectable limits
***Estimated value, detected below Practical Quantitation Limit
Units mg/L unless otherwise noted. Values in bold are elevated compared to water quality standards or U.S. EPA recommended reference condition values.

4.0 Discussion

4.1 Possible Effects of Elevated Sulfate and Chloride Levels

Although sulfate and chloride levels were elevated during this study compared to other local streams, MSCI scores did not indicate that the macroinvertebrate community in Blackberry Creek was impaired compared to reference conditions. A closer look at the macroinvertebrate samples, however, suggests that the levels of sulfate and chloride present in Blackberry Creek may have affected the macroinvertebrate community structure. With the exception of the fall 2010 Blackberry Creek #1 sample, Ephemeroptera made up a higher percentage than reference conditions. Most of this percentage, however, was made up of the tolerant *Caenis latipennis*. Other mayfly taxa, such as heptageniid mayflies *Stenacron* and *Stenonema femoratum* and leptophlebiid mayflies, were more common in biological criteria samples than the Blackberry Creek samples. A study by Pond et al. (2008) found that stream reaches with elevated levels of conductivity (>500 µS/cm), sulfate (mean of 695.5 mg/L), and chloride (mean of 4.6 mg/L) in the Appalachian Mountain coal mining region in Kentucky, Virginia, and West Virginia had impaired macroinvertebrate communities. The stream reaches in this study were below mountain top removal coal activities. Due to lower sulfur concentrations in the coal of this area, mine drainage tended to be more alkaline (pH>7) than other coal mining regions. In these impaired stream reaches, EPTT, Ephemeroptera taxa richness, percent Ephemeroptera, and Shannon Diversity Index were lower and biotic index was higher than unmined control streams in the study. Mayflies in the families Ameletidae, Baetidae (except the genus *Plauditus*), Ephemerellidae, Heptageniidae, and Leptophlebiidae were much less abundant or were not present at all in mined streams compared to unmined streams. Previous studies have shown that osmoregulation effects caused by elevated conductivity levels can be toxic to mayflies because they have a high cuticle permeability and regulate ion uptake using specialized chloride cells on their gills, integument, and the internal Malpighian tubules (Wichard et al. 1973, Komnick 1977, Gaino and Rebora 2000). It is not known why the high levels of sulfate and chloride did not have more of an effect on the Blackberry Creek MSCI scores. One possible explanation is that the native macroinvertebrate community in Blackberry Creek and other streams in South Deepwater AES type are made up of tolerant macroinvertebrate taxa that can withstand harsh conditions that can occur in these streams such as low base flows, low dissolved oxygen levels, turbid water, and high levels of bottom sediment. These stream conditions are vastly different than the high gradient, clear water, gravel bottom streams of the Appalachian Mountains that have a native macroinvertebrate community that is more diverse and less tolerant of water quality impairments.

4.2 Other Factors Affecting Macroinvertebrate Community Structure

Blackberry Creek #2 had lower MSCI scores than Blackberry Creek #1 during both sampling seasons, which may have been caused by poorer stream habitat quality and local land use rather than elevated levels of sulfate and chloride (Table 2). Sedimentation and epifaunal substrate were much worse at Blackberry Creek #2 and were most likely caused by a dam on Blackberry Creek downstream of the sampling reach. The sampling

reach seemed to be located in a section of the stream in which the hydrology had been altered by the dam that caused a decrease in stream flow and led to sediment falling out of the water column and being deposited on the stream bottom. Local land use also may have affected stream habitat quality and the macroinvertebrate community. During the spring 2011 sampling season, cattle were observed having access to the stream. This observation, along with some habitat parameters like poor riparian zone for the right bank and poor or marginal quality for bank vegetative protection, indicates that cattle could be causing additional sedimentation problems within the stream reach.

Some of the FFGs and FHGs indicated that sedimentation may have affected the macroinvertebrate community structure while others did not. Rabeni et al. (2005) classified FFG for sediment tolerance from intolerant to tolerant in the following order: filterers < scrapers < predators < gatherer-collectors < shredders and for FHGs from intolerant to tolerant in the following order: clingers < swimmers < sprawlers < climbers < burrowers. Sediment intolerant filterers were much less abundant at station #2 than station #1 during both sampling seasons even though the station #2 values were higher than reference conditions during the fall 2010 sampling season and only slightly lower during the spring 2011 sampling season. Scrapers, another sediment intolerant FFG, did not show as strong of a relationship of decreased abundance with increased amounts of sediment. Scrapers were present in higher numbers at station #2 than both station #1 and reference conditions during the fall 2010 sampling season, but were slightly lower than station #1 and reference conditions during the spring 2011 sampling season. The sediment tolerant gatherer-collectors and shredders did not show a strong relationship with increased amounts of sediment at station #2. Gatherer-collectors were slightly higher at station #2 than both station #1 and reference conditions during the fall 2010 sampling season. During the spring 2011 sampling season, gatherer-collectors abundance was similar to reference conditions at station #2 and slightly higher than station #1. Gatherer-collectors were present in similar numbers compared to reference conditions at station #2 during the spring 2011 sampling season. At station #2, shredders were lower in abundance than station #1 and also lower than reference conditions during the fall 2010 sampling season. Shredders were higher in abundance at station #2 than station #1 but were lower than reference conditions during the spring 2011 sampling season.

Sediment intolerant FHG clingers were much less abundant during the fall 2010 sampling season and slightly less abundant during the spring 2011 sampling season at station #2 than both station #1 and reference conditions. Results for sediment tolerant FHG burrowers was inconclusive with values lower at station #2 than station #1 and reference conditions during the fall 2010 sampling season, but higher at station #2 than station #1 and reference conditions during the spring 2011 sampling season. Climbers, the other sediment tolerant FHG, was much higher at the Blackberry Creek test stations than reference conditions during both sampling seasons, but was only higher at Blackberry Creek #2 compared to Blackberry Creek #1 during the fall 2010 sampling season. It is not known what is driving the higher abundance of climbers at Blackberry Creek, but the results were inconclusive as it related to sediment since estimated levels of sediment were

much higher at Blackberry Creek #2 than Blackberry Creek #1. The results from FFG and FHG analyses indicated that some of the feeding groups and habitat groups like filterers and clingers showed the expected response to high levels of sediment, but other groups like scrapers, gather-collectors, shredders, burrowers, and climbers either did not show the expected response or the results were inconclusive, differing by sampling season.

Most of the individuals and taxa collected in the Blackberry Creek samples had biotic index values in the moderately tolerant to tolerant range (Tables 6 through 9). During the fall 2010 sampling season, taxa with biotic index values ≥7.5 were more abundant at station #2 and biocriteria reference sites than station #1. Taxa with these tolerant biotic index values made up about 61 percent of the sample at station #2 and biocriteria reference sites and 49 percent at station #1. Taxa with biotic index values below 5.0 were not very abundant at either Blackberry Creek station and were much lower than reference conditions. The five most abundant taxa found at station #2 had biotic index values ranging from 6.4 for *Dubiraphia* to 7.9 for *Hyalella azteca*. The most abundant taxa at station #2, making up almost a quarter of the sample, was *Caenis latipennis* with a biotic index of 7.6. At station #1 the five most abundant taxa had biotic index values ranging from 6.7 for *Tanytarsus* to 9.1 for *Physella*. *Tanytarsus* was the most abundant taxon found at station #1, making up 22 percent of the sample.

During the spring 2011 sampling season, taxa with biotic index values ≥7.5 were more abundant at station #2 than station #1 and biocriteria reference sites. Taxa with these tolerant biotic index values made up about 61 percent of the sample at station #2, 54 percent at station #1, and 49 percent for reference conditions. Both Blackberry Creek stations had a much smaller percentage of the samples made up of taxa with biotic index values below 5.0 compared to reference conditions. The five most abundant taxa found at station #2 had biotic index values ranging from 6.5 for *Cricotopus/Orthocladius* group to 9.2 for tubificid worms. Unlike the fall 2010 sample, in which *Caenis latipennis* was the dominant taxa, three dominant taxa—*Cricotopus/Orthocladius* group, tubificid worms, and *Dicrotendipes*—each made up about 15 percent of the sample for the spring 2011 sample. At station #1, the five most abundant taxa had biotic index values ranging from 6.5 for *Crictopus/Orthocladius* group to 8.0 for hydrobiid snails. Two chironomid taxa, *Tanytarsus* and *Dicrotendipes*, made up over half of the individuals in the station #1 sample. The higher abundance of *Tanytarsus* at station #1 compared to station #2 during both sampling seasons could indicate that the increased sedimentation at station #2 was affecting *Tanytarsus* abundance. *Tanytarsus* is a sediment intolerant filterer FFG taxa and is an important biological indicator. The state of Ohio currently uses the biological metric Percent Tanytarsini (the taxonomic tribe in which *Tanytarsus* is classified) as one of the metrics for the state's Invertebrate Community Index (Deshon 1995). In Ohio, Tanytarsini taxa are often the predominant midge group at reference sites. Chironomids in Tanytarsini generally are considered intermediate in pollution tolerance and can decline or disappear under moderate pollution stress. Other Tanytarsini taxa such as *Cladotanytarsus, Micropsectra, Paratanytarsus*, and *Rheotanytarsus* were found in the

Blackberry Creek samples but in much lower numbers than *Tanytarsus*. *Paratanytarus*, which is classified as a sediment tolerant gatherer-collector FFG and intermediate sediment tolerant sprawler FHG, was the only other Tanytarsini taxon that made up at least 1 percent of the Blackberry Creek samples. *Partanytarsus* at Blackberry Creek #2 made up 1.8 percent of the sample during the fall 2010 sampling season and 1.6 percent during the spring 2011 sampling season, but only 0.2 percent during the fall 2010 sampling season and 0.1 percent during the spring 2010 sampling season at Blackberry Creek #1.

5.0 Conclusions

The MSCI scores were in the fully supporting range at both sampling stations during the fall 2010 and spring 2011 sampling seasons. With the exception of *Caenis latipennis*, there was some evidence that mayfly diversity and density may have been reduced because of high sulfate, high chloride, or other factors such as elevated sedimentation. Other biological metrics such as percent filterer FFG, percent clinger FHG, and percent Tanytarsini midges indicated that increased sedimentation may have affected the macroinvertebrate community at Blackberry Creek #2.

The first null hypothesis stated that the macroinvertebrate community will not differ between longitudinally separate reaches of Blackberry Creek. The second null hypothesis stated that the macroinvertebrate community in Blackberry Creek will not differ from the glide/pool biological criteria for the Central Plains/ Osage/South Grand EDU. These two null hypotheses were accepted based on the results of the MSCI scores even though other biological metrics indicated that the macroinvertebrate community may have been altered by elevated levels of sulfate and chloride at both sampling stations and by sediment at Blackberry Creek #2.

The third hypothesis stated that stream habitat assessment scores will not differ between longitudinally separate reaches of Blackberry Creek. The fourth hypothesis stated stream habitat assessment scores in Blackberry Creek will not differ from Little Drywood Creek, a glide/pool biological criteria reference stream in the Central Plains/Osage/South Grand EDU. The third and fourth null hypotheses were accepted based on the stream habitat scores. Stream habitat assessment results indicated that both sampling stations should have comparable macroinvertebrate habitat to reference conditions. The stream habitat score at Blackberry Creek #2 was much lower than Blackberry Creek #1 and Little Drywood Creek, but still was greater than 75 percent of the habitat score at Little Drywood Creek. The habitat assessment did show elevated levels of sediment at Blackberry Creek #2 that could have affected the macroinvertebrate community since MSCI scores at this station were lower during both sampling seasons.

The fifth hypothesis stated physicochemical water quality in Blackberry Creek will meet the Water Quality Standards of Missouri (MDNR 2010a). The sixth hypothesis stated physicochemical water quality will not differ between longitudinally separate reaches of Blackberry Creek. The fifth and sixth null hypotheses were accepted based on the results

of the water samples. The results from the water samples did not show any violations of the Missouri Water Quality Standards even though sulfate and chloride concentrations were elevated at the Blackberry Creek sampling stations during both sampling seasons compared to values collected at two local streams.

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Submitted by: ____

Carl Wakefield
Environmental Specialist
Water Quality Monitoring Section
Environmental Services Program

Date: ____

Approved by: ____

Larry Groner
Acting Director
Environmental Services Program

LG:cwt

c: John Ford, QAPP Project Manager, WPP

Appendix A

Blackberry Creek Macroinvertebrate Taxa Lists

Aquid Invertebrate Database Bench Sheet Report
Blackberry Cr [1004124], Station #2, Sample Date: 10/5/2010 2:30:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina	6	5	9
AMPHIPODA			
Hyalella azteca	22	14	63
COLEOPTERA			
Berosus		1	1
Dubiraphia	50	34	16
Dytiscidae		1	
Neoporus	1	3	
Scirtidae		14	1
Stenelmis		1	
DECAPODA			
Orconectes virilis		1	
DIPTERA			
Ceratopogoninae	9		1
Chironomidae	1		
Chironomus	1		3
Chrysops		1	
Cladopelma	14		7
Corynoneura			1
Cricotopus bicinctus			1
Cryptotendipes	1		1
Dicrotendipes	20	13	66
Forcipomyiinae		2	
Glyptotendipes			5
Labrundinia	20	22	13
Nanocladius	2	7	3
Parachironomus	1	1	
Paratanytarsus	10	4	4
Polypedilum illinoense grp	1	1	4
Procladius		1	
Pseudochironomus			2
Tanypus	5		
Tanytarsus	16	18	16
Tribelos		7	70
EPHEMEROPTERA			
Apobaetis	1		
Caenis latipennis	124	68	45
Callibaetis	4	1	5
Hexagenia limbata	4		

Aquid Invertebrate Database Bench Sheet Report
Blackberry Cr [1004124], Station #2, Sample Date: 10/5/2010 2:30:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Stenacron			2
HEMIPTERA			
Microvelia		1	
Ranatra nigra			-99
ISOPODA			
Lirceus		1	
LIMNOPHILA			
Ancylidae			1
Menetus	6	2	1
Physella	4	14	3
MEGALOPTERA			
Sialis			-99
ODONATA			
Argia		22	1
Enallagma	9	47	4
Epicordulia	-99	-99	
Erythemis			-99
Pachydiplax longipennis	-99		1
TRICHOPTERA			
Cyrnellus fraternus		1	
Hydroptila	1		
Oecetis		2	1
Oxyethira	1		1
TUBIFICIDA			
Aulodrilus		1	
Limnodrilus hoffmeisteri			1
Tubificidae	2	4	
VENEROIDA			
Pisidiidae	12		

Aquid Invertebrate Database Bench Sheet Report
Blackberry Cr [1004125], Station #1, Sample Date: 10/6/2010 8:45:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina	3	9	8
AMPHIPODA			
Hyalella azteca		4	1
ARHYNCHOBDELLIDA			
Erpobdellidae		-99	
COLEOPTERA			
Berosus		2	
Dubiraphia	1	16	3
Dytiscidae			1
Scirtidae		10	2
Stenelmis		1	
DIPTERA			
Ablabesmyia	11	7	6
Anopheles		1	
Ceratopogoninae	7	3	1
Chironomidae	4	1	6
Chironomus			3
Cladopelma	1		
Clinotanypus	1	4	1
Cricotopus/Orthocladius			1
Cryptochironomus	1		1
Cryptotendipes	31		
Dicrotendipes	38	23	83
Forcipomyiinae		2	
Glyptotendipes			2
Labrundinia	3	5	3
Nanocladius	1		
Parakiefferiella	1	1	1
Paratanytarsus		1	1
Polypedilum halterale grp	14	1	
Polypedilum illinoense grp		6	2
Procladius	8		1
Stenochironomus			4
Tanypus			1
Tanytarsus	98	83	40
Tribelos	6	12	73
EPHEMEROPTERA			
Caenis latipennis	6	6	22
Callibaetis	23	3	3

Aquid Invertebrate Database Bench Sheet Report
Blackberry Cr [1004125], Station #1, Sample Date: 10/6/2010 8:45:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Heptageniidae	1		
Hexagenia limbata	3		
Stenacron	3		
Stenonema femoratum	2		
LIMNOPHILA			
Ancylidae	1		
Helisoma	-99	-99	-99
Lymnaeidae	66	5	7
Menetus	2	6	3
Physella	4	52	4
Planorbella	1		
MEGALOPTERA			
Sialis	1	-99	
ODONATA			
Anax		1	
Argia	1	16	-99
Enallagma	1	19	1
Epicordulia		-99	
Erythemis			1
Gomphidae	4		
Gomphus		-99	
Ischnura		5	
Libellulidae		2	
Macromia	1		1
Neurocordulia			-99
Pachydiplax longipennis	3		3
RHYNCHOBDELLIDA			
Glossiphoniidae			1
TRICHOPTERA			
Hydroptila			1
Oecetis	16	3	
Oxyethira			4
TRICLADIDA			
Planariidae		2	1
TUBIFICIDA			
Aulodrilus	4		
Ilyodrilus templetoni	1		
Tubificidae	22	1	
VENEROIDA			
Corbicula		-99	

Aquid Invertebrate Database Bench Sheet Report
Blackberry Cr [1004125], Station #1, Sample Date: 10/6/2010 8:45:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Pisidiidae	3	2	

Aquid Invertebrate Database Bench Sheet Report
Blackberry Cr [110343], Station #1, Sample Date: 3/31/2011 8:45:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina	1	9	2
AMPHIPODA			
Hyalella azteca		25	1
ARHYNCHOBDELLIDA			
Erpobdellidae			1
COLEOPTERA			
Berosus			4
Dubiraphia	2	6	
Dytiscidae		1	
Peltodytes			1
Scirtidae		6	2
DECAPODA			
Orconectes virilis		-99	
DIPTERA			
Ablabesmyia	4	7	
Ceratopogoninae	8		2
Chironomidae	2		1
Chironomus	1		
Cladopelma	6		3
Cladotanytarsus		1	
Clinotanypus	4	2	1
Cricotopus/Orthocladius	5	11	24
Cryptochironomus	1		1
Cryptotendipes	18	1	1
Dicrotendipes	50	37	153
Diptera		1	1
Forcipomyiinae			1
Hydrobaenus	5	4	2
Labrundinia	2	4	1
Micropsectra	1		
Nilothauma			1
Parachironomus		1	
Parakiefferiella		3	1
Paraphaenocladius	1	1	2
Polypedilum halterale grp	6	2	
Polypedilum illinoense grp	2	13	5
Polypedilum scalaenum grp			2
Procladius	1		
Pseudochironomus		1	

Aquid Invertebrate Database Bench Sheet Report
Blackberry Cr [110343], Station #1, Sample Date: 3/31/2011 8:45:00 AM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Stenochironomus			1
Tanypus	3		
Tanytarsus	120	86	58
Thienemannimyia grp.			1
Tribelos		1	2
EPHEMEROPTERA			
Caenis latipennis	73	24	15
Stenacron			1
LIMNOPHILA			
Ancylidae	2		1
Helisoma		2	-99
Menetus		3	
Physella		4	4
Planorbella			1
MEGALOPTERA			
Sialis	1		
MESOGASTROPODA			
Hydrobiidae	25	9	6
ODONATA			
Argia	1	1	1
Enallagma		6	
Epicordulia	-99	1	
Gomphidae	1		
Gomphus	-99	1	
Libellula		1	-99
Libellulidae	2	1	
TRICHOPTERA			
Hydroptila	2	5	9
Oecetis	1	1	
TRICLADIDA			
Planariidae		1	
TUBIFICIDA			
Enchytraeidae	1		
Ilyodrilus templetoni	5	1	
Limnodrilus hoffmeisteri		1	
Quistradrilus multisetosus	5		
Tubificidae	18	8	1
VENEROIDA			
Pisidiidae			2

Aquid Invertebrate Database Bench Sheet Report
Blackberry Cr [110344], Station #2, Sample Date: 3/30/2011 4:15:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
"HYDRACARINA"			
Acarina		2	
AMPHIPODA			
Hyalella azteca		47	5
COLEOPTERA			
Berosus		1	1
Dubiraphia	22	13	12
Dytiscidae	1	2	1
Scirtidae		3	5
DECAPODA			
Orconectes virilis			-99
DIPTERA			
Ablabesmyia		1	
Ceratopogoninae	22	1	1
Chironomidae		6	1
Chironomus	5		
Cladopelma	35		1
Cladotanytarsus	3	1	
Cricotopus bicinctus	1		
Cricotopus/Orthocladius	10	82	59
Cryptotendipes	11	1	1
Dicrotendipes	28	18	109
Diptera		2	8
Einfeldia	2		
Glyptotendipes			10
Hydrobaenus	1	1	4
Labrundinia		3	
Parakiefferiella		2	4
Paratanytarsus	2	10	4
Paratendipes	1		
Polypedilum illinoense grp	1	26	22
Polypedilum scalaenum grp			1
Pseudochironomus		1	1
Rheotanytarsus	1	1	3
Stictochironomus	1		
Tanypus	3		
Tanytarsus	31	11	22
Thienemanniella		1	1
Thienemannimyia grp.			2
Tribelos			5

Aquid Invertebrate Database Bench Sheet Report
Blackberry Cr [110344], Station #2, Sample Date: 3/30/2011 4:15:00 PM
NF = Nonflow; RM = Rootmat; SG = Woody Debris; -99 = Presence

ORDER: TAXA	NF	RM	SG
Zavrelimyia		3	4
EPHEMEROPTERA			
Baetis	2		
Caenis latipennis	53	49	13
Callibaetis	1		
Hexagenia limbata	3		
ISOPODA			
Lirceus		7	
LIMNOPHILA			
Gyraulus		2	
Physella		2	3
MEGALOPTERA			
Sialis	1		
ODONATA			
Anax		-99	
Argia		1	2
Basiaeschna janata		-99	
Enallagma	1	11	
Gomphus	-99		
Ischnura		1	
Macromia		-99	
Nasiaeschna pentacantha		-99	
TRICHOPTERA			
Hydroptila			6
Pycnopsyche		1	
TUBIFICIDA			
Enchytraeidae		1	3
Ilyodrilus templetoni			1
Limnodrilus hoffmeisteri	4		1
Tubificidae	124	5	20
VENEROIDA			
Pisidiidae	2	1	3